Marine Physical Laboratory

Upgrading the Day/Night Whole Sky Imager from Manual/ Interactive to Full Automatic Control

Janet E. Shields, Richard W. Johnson, and Monette E. Karr

Final Report to the
Office of Naval Research
Contract N00014-89-D-0142 (DO#18)
For the Period 1-1-91 - 5-31-93

MPL-U-140/94
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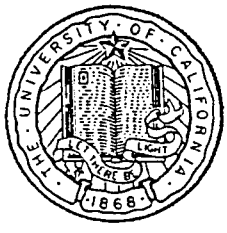

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The Whole Sky Imager (WSI) is a ground-based system for assessment of cloud cover over the full upper hemisphere. Using a fish-eye lens and a slow scan CCD sensor, it acquires imagery through daylight, into moonlight and starlight conditions. At the start of this contract, the new Day/Night WSI was in brassboard configuration. This contract funding enabled MPL to complete assembly of the system, acquire system calibrations for measuring system characteristics, and develop algorithms for control of the system.. The WSI was fielded and cloud decision algorithms were developed based on the acquired test data.

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Abstract

The Whole Sky Imager (WSI) is a ground-based system for assessment of cloud cover over the full upper hemisphere. Using a fish-eye lens and a slow scan CCD sensor, it acquires imagery through daylight, into moonlight and starlight conditions. At the start of this contract, the new Day/Night WSI was in brassboard configuration. This contract funding enabled MPL to complete assembly of the system, acquire system calibrations for measuring system characteristics, and develop algorithms for control of the system. The WSI was fielded, and cloud decision algorithms were developed based on the acquired test data.

Introduction

The Day/Night Whole Sky Imager (WSI) is a ground-based system for assessment of cloud cover over the full upper hemisphere. Using a fish-eye lens and a slow scan CCD sensor, it acquires imagery through daylight, into moonlight and starlight conditions. At the start of this contract, the new Day/Night WSI was in brassboard configuration. This contract funding enabled MPL to complete assembly of the system, acquire system calibrations for measuring system characteristics, and develop algorithms for control of the system, field and test the WSI, and develop cloud decision algorithms.

This work has been completed. The instrument was delivered within the contract period, along with extensive documentation. It is under continuing use at the sponsor's site.

Approach

The work under this contract entailed:

a. Complete the packaging and operational testing of the electromechanical sub-assemblies. These sub-assemblies include, but are not limited to the MPL, custom dual interface, the MPL occultor drive, and the external environmental control cabinet.

b. Characterize camera performance and develop decision algorithms to enable a computer specification of an optimized data acquisition sequence prior to the interactive image acquisition. These decision algorithms include, but are not limited to, sun and moon ephemeris generation for specification for orientation of the solar/lunar occultor, spectral and neutral density selections, and exposure time specification for imager control.

c. Based on the slow scan camera system characteristics, revise the daylight algorithms to yield reliable ratios for both daylight and moonlight conditions. For daytime only, revise the variable threshold algorithm used with the Day WSI to apply to these ratios with the intent of yielding daytime cloud decision images.

d. Integrate the algorithms outlined in Sections (b) and (c) above into an interactive software package. Provide a technical progress report.

These contract requirements have been completed. At the request of the sponsor, the requirement for a progress report was met via a combination of memos and verbal reports. In addition, a portion of the program options were funded, and these were completed. These options were:

Option A: Continue development of the variable threshold algorithm with the intent of yielding cloud decision images under moonlight condition.

Option B: Complete computer interface with the electro-mechanical subsystems discussed in Item (a) for computer control of image acquisition. Complete geometric field of view calibration.

Option C: Prepare a final report.

Option D: Test system under full operational configuration.

This work was documented and discussed in Technical Note 234, which was delivered to the sponsor and can be obtained through MPL.

The final contract requirement is documented in the Addendum to the Statement of Work (UCSD 92-1101-R1). Delivery of these items were

completed and documented in a letter to Major Dorsey (dtd 18 June 1993).

Discussion

This project resulted ultimately in the fielding of a very useful and powerful instrument. The new Whole Sky Imager (WSI) can acquire data on the cloud field from full daylight conditions, all the way down to starlight. Some of the enabling development involved hardware. This included completing the environmental housing, and providing the computer interfaces for system control.

Much of the development involved characterization of the environmental conditions and algorithms to handle them. For example, it was necessary to determine a reasonable way to characterize the lunar motion, and thus control the solar/lunar occultor to block both the sun and the moon. One of the most important algorithms is the flux control algorithm, which sets the exposure and filter selection on the WSI. This development required research into the expected changes in overall irradiance levels and sky radiance values in the sky as a function of time. This is dependent on solar elevation, and lunar elevation, phase, and distance from the earth. Models of this behavior led to initial algorithms, which were then tested using field data. The resulting algorithm has proved quite reliable in providing appropriate WSI exposure and filter selections.

Software was an ongoing task. Automated control of the WSI was programmed. This included controlling the above hardware interfaces and algorithms, integrating in control of timing and peripherals, and providing apprpriate user interfaces.

Development of algorithms for detection of the clouds under both daylight and moonlight was an additional major thrust. This included calibration of the system and evaluation of the impact of the calibrations on the data. Development of the software to evaluate the field data was required. This was followed by development of the actual ratio image code, as well as the cloud decision code.

The instrument has been fielded, and performs quite well, The raw data are outstanding, providing clean digital images of the clouds and sky. The system can now be run interactively or automatically, and the user

can use either the raw data, ratios, or cloud decision images under daylight and moonlight.

Conclusion

The Day/Night WSI fielded under this delivery order has been very productive in test support for the sponsors. The system provides information regarding both the cloud features and the radiant background of the scene. The statement of work for this contract has been successfully completed.

Acknowledgements

We would like to express our appreciation to Major Tom Dorsey at Air Force Phillips Lab for his support and advice.

Reference

1. Shields, J. E., Johnson, R. W., Koehler, T. L., and Karr, M. E. "Automated Whole Sky Imagers For Day and Night Cloud Field Assessment." Optical Systems Group Technical note No. 234, Marine Physical Laboratory, Scripps Institution of Oceanography, San Diego, CA (May 1993).

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